ZooKeys 511: 69–79 (2015)
doi: 10.3897/zookeys.511.9572
http://zookeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

In the shadow of a megalopolis, a new *Flexamia* from a threatened grass species in the New Jersey Pine Barrens (Hemiptera, Cicadellidae, Deltocephalinae, Paralimnini)

Andrew Hicks[1]

1 *University of Colorado, Museum of Natural History, Entomology Section, Boulder, CO USA*

Corresponding author: *Andrew Hicks* (andrew.hicks@colorado.edu)

Academic editor: *A. Sanborn* | Received 12 March 2015 | Accepted 3 June 2015 | Published 2 July 2015

http://zoobank.org/90D386CE-9F7C-4E3C-8864-EEA264FD7717

Citation: Hicks A (2015) In the shadow of a megalopolis, a new *Flexamia* from a threatened grass species in the New Jersey Pine Barrens (Hemiptera, Cicadellidae, Deltocephalinae, Paralimnini). ZooKeys 511: 69–79. doi: 10.3897/zookeys.511.9572

Abstract

A previously unknown species of the North American leafhopper genus *Flexamia, F. whitcombi* **sp. n.**, is described from pinebarren smokegrass (*Muhlenbergia torreyana* (Schult.) Hitchc.), a state-listed threatened grass in the New Jersey Pine Barrens. The *serrata* species group, to which it belongs, is redefined and a key to the species of the group is provided. This is the first reported insect association with *M. torreyana*.

Keywords

Hemiptera, Cicadellidae, Deltocephalinae, leafhopper, *Flexamia*, new species, *Muhlenbergia torreyana*, New Jersey Pine Barrens

Introduction

Flexamia is a charismatic North American leafhopper genus of specialist grass feeders with the species typically feeding upon a single, widespread host species. The hosts they spend their lives on include some of the iconic grasses of the American prairie, rangelands, and deserts, and *Flexamia* are often described as prairie or grassland leafhoppers. By these standards, the new species described herein is an outlier, occurring in the most densely populated state in the US where its host *Muhlenbergia torreyana* (Schult.)

Copyright *Andrew Hicks*. This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Hitchc. grows, though neither New Jersey nor the Pine Barrens—also known as the New Jersey Pinelands—are usually thought of in a grassland context.

Known colloquially as pinebarren smokegrass, Torrey's dropseed, Torrey's muhly, and New Jersey muhly, *Muhlenbergia torreyana* is a native perennial C4 Chloridoid grass, considered either to be a southern coastal plains species at or near the northern edge of its range in New Jersey (Caiazza and Fairbrothers 1980; McAvoy and Wilson 2014), or a species with centers of distribution in both the New Jersey Pine Barrens and the coastal plain of the Carolinas (Sorrie et al. 1997). *M. torreyana* is rare further south (ibid), with only 13 populations in North Carolina (North Carolina Natural Heritage Program 2015) and "a few" occurrences in Tennessee (NatureServe 2015). Apparently extirpated in parts of its former range including New York (Zaremba and LaMont 1993), *M. torreyana* is locally abundant in wet meadows and seasonally flooded depressions in the Pine Barrens (Fig. 1) and its status is listed as threatened in New Jersey (Special Plants of New Jersey 2013). This is the first report of a leafhopper—or any other insect—using this plant as a host and represents a departure for a member of the species group *serrata* which were previously known only from *Muhlenbergia richardsonis* (Trin.) Rydb. (Whitcomb and Hicks 1988, Bess and Hamilton 1999).

Because of the similarity of its specific epithet, it is also occasionally confused with *Muhlenbergia torreyi* (Kunth) Hitchc. ex Bush, a species known as ring muhly from the southwestern USA.

Materials and methods

Thirty-five specimens (excluding juveniles) belonging to the new taxon were collected on the host plants by sweeping in two localities. Dissection, measurements, and photographs were completed with the use of a stereo microscope with a digital camera attachment. Genitalia were prepared following techniques found in Oman (1949) and Young and Beirne (1958). Photographs were processed with Helicon Focus photo-stacking software and post-processed using the 5th generation of the standard image-editing software. Micrographs of the aedeagus were acquired using a JEOL JSM-6480 Scanning Electron Microscope.

Systematics

The *serrata* species group of the genus *Flexamia* was erected by Whitcomb and Hicks (1988) for *F. serrata* Beamer & Tuthill based on the morphology the aedeagal apex, specifically the presence of the pair of dorsal processes. To accommodate *F. huroni* Bess & Hamilton, in which the paired processes were described as apicolateral or lateral terminal, not dorsal, the *serrata* group is redefined here as having 5 or more unbranched processes on the aedeagal apex.

***Flexamia whitcombi* sp. n.**
http://zoobank.org/10051907-42E6-4AB7-BFD1-7808B5C701AA

Description. Length of male 3.5–3.8 mm, length of female 3.7–4.2 mm; head with length of crown ca. 1.5 times interocular width and ca. 0.68 times transocular width. Base color of dried specimens (Figs 2 & 3) usually stramineous, occasionally ivory above, venter entirely or partially fuscous often lighter caudally, occasionally merely stramineous; crown and pronotum without well-defined fuscous spots or stripes except for pair of dark spots at crown apex. Fore-wing typical of the genus, a few scattered small irregular fuscous markings present, veins slightly paler, apex of the abdomen usually exposed on female specimens.

Face (Fig. 4) coloration varies but typically heavily pigmented apically and laterally, paler medially, 5–6 fine pale transverse lines between eyes not meeting medially, apex of clypellus dark.

Male genitalia. Pygofer (Fig. 5), with posterior lobe truncate apically, caudoventral margin heavily sclerotized, angled and terminating ventrally in a rounded process bearing fine denticulation. Subgenital plates short, extending about 2/3 length of pygofer (Fig. 6), apices relatively blunt, rounded. Connective fused to the aedeagus, keel extending dorsad slightly less than half the height of the dorsal apodeme (Fig. 7). Styles typical of the genus. Aedeagus symetrical, straight in ventral aspect (Fig. 8); in lateral aspect (Fig. 7) shaft long, recurved, tapering evenly before expanding apically, apex (Fig. 9) with 5 processes: on the caudoventral surface, extending laterally and curved ventrad, one pair of short, stout divergent processes with blunt apices, also on the caudoventral surface a longer acute unpaired process extending basad, curved ventrad and bearing the gonopore (Fig. 9C) in the form of a slit extending from the apex of the aedeagal shaft ending subapically on the unpaired process; on the dorsal surface a pair of long spine-like processes which usually cross over the shaft of the aedeagus (Fig. 9A, B). Both apex of shaft and pygofer process occasionally visible in undissected specimens.

Female. Posterior margin of abdominal sternum VII (Fig. 10) typical of the genus, shallowly concave on either side of the slightly notched and embrowned median convex lobe; ovipositor with bases of first valvulae as in Figure 11.

Material examined. Holotype male, USA: NEW JERSEY: Atlantic Co., Mullica Twp., Batso Fireline Rd., 8.5km SE of Atsion, 27 July 2012 ALHicks, ca. 25 ft asl, 39.6798°N, 74.6705°W. Swept from *Muhlenbergia torreyana*. 6 male and 11 female paratypes, same data.

7 male and 3 female paratypes, NEW JERSEY: Burlington Co., Washington Twp., 10.1 km SE of Atsion, Batso Lk. Rd., 27 July 2012 ALHicks, ca. 20 ft asl, 39.6667°N, 74.6501°W.

Holotype and paratypes in the entomology collection of the University of Colorado Museum of Natural History (UCMC); paratypes in the collection of the United States National Museum of Natural History (USNM).

Figure 1. A stand of *Muhlenbergia torreyana* in the Pine Barrens. Photo courtesy of Uli Lorimer of the Brooklyn Botanic Garden.

Figure 2. Habitus, male, lateral aspect.

Etymology. The specific epithet honors an extraordinary mentor, colleague and friend, the late Dr. Robert Whitcomb, who made, among many other accomplishments, major contributions to leafhopper taxonomy and ecology.

Diagnosis. *F. whitcombi* is included in the *serrata* species group by characters of the male genitalia but easily distinguished from the related *F. serrata* and *huroni* by

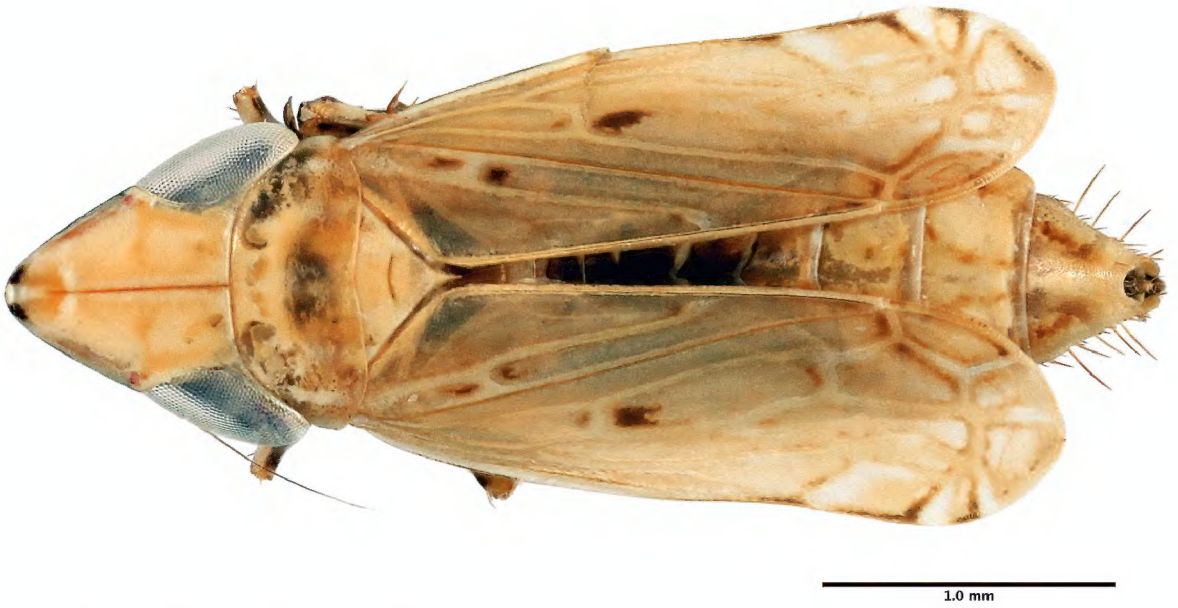

Figure 3. Habitus, female, dorsal aspect.

Figure 4. Face, ventral aspect, showing variation in amount of pigmentation.

Figure 5. Pygofer and subgenital plates, male, lateral aspect. Note heavily sclerotized caudoventral margin (arrow) and length of subgenital plates relative to pygofer.

Figure 6. Subgenital plates, ventral aspect, outlined for clarity.

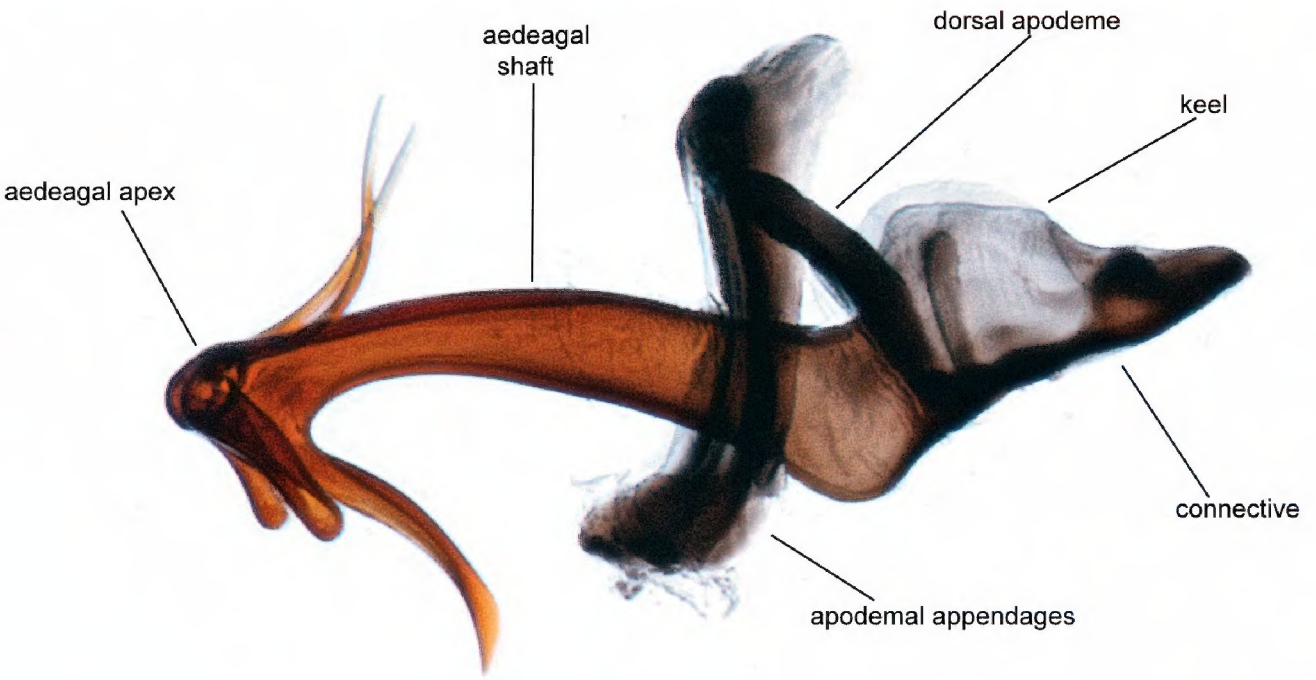

Figure 7. Aedeagus, connective, lateral aspect.

Figure 8. Aedeagus, connective, ventral aspect.

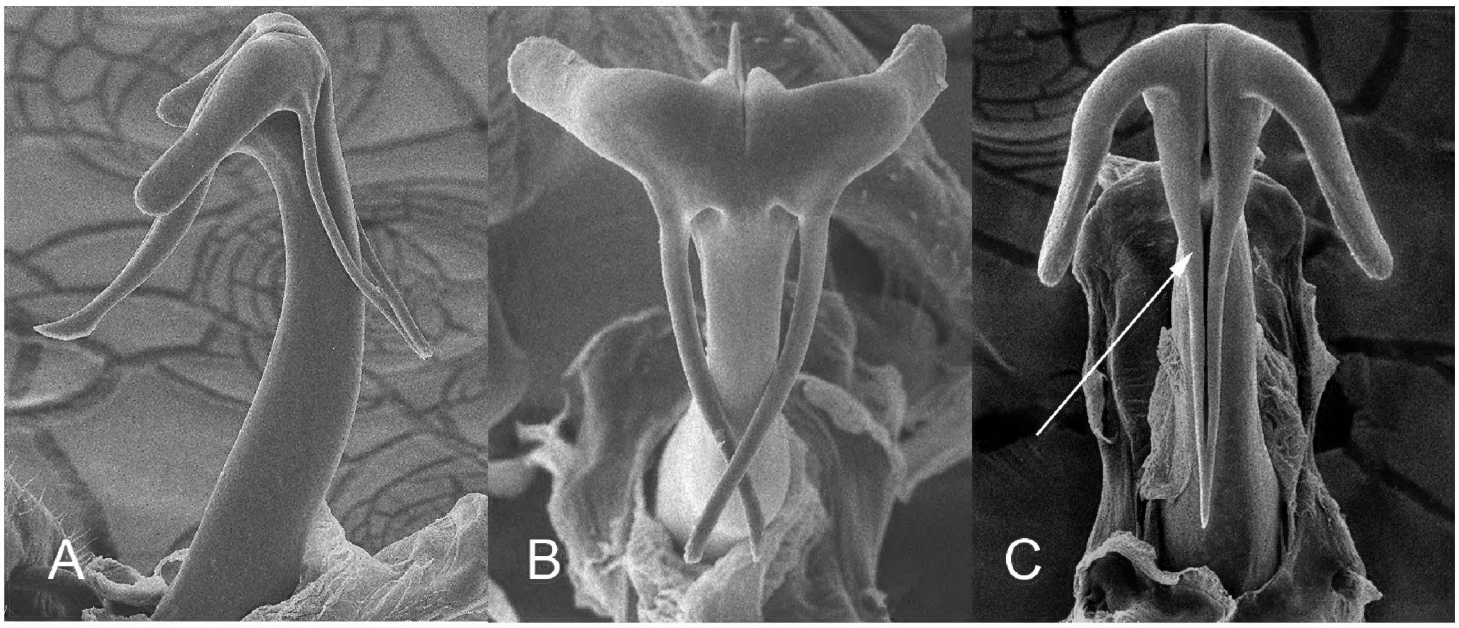

Figure 9. SEMs of the aedeagal apex, from left to right, lateral, dorsal, and caudoventral aspects, the latter illustrating the position of the gonopore on the ventral unpaired process.

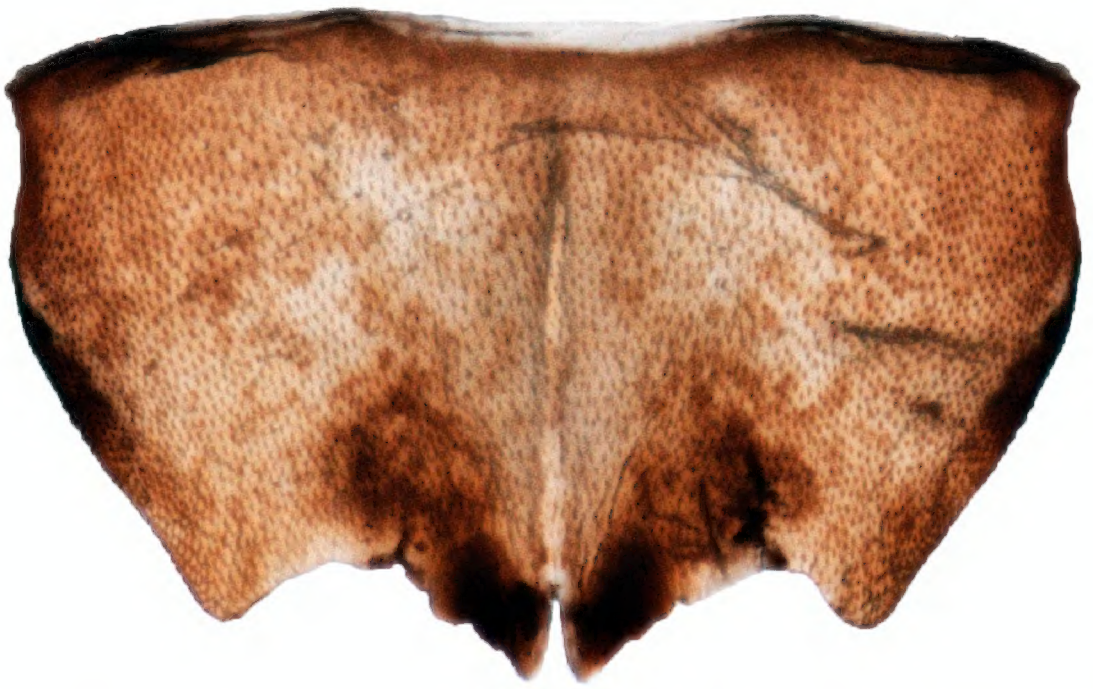

Figure 10. Female 7th sternite. Commonly illustrated for this genus but only occasionally useful to separate species.

its habitus (dark below and stramineous above). In addition, males can be separated from all other species by the denticulate ventral pygofer process and by the apex of the aedeagus, females by the bases of the valvulae (Fig. 11). Because of its habitus and distribution, it is likely to be mistaken for other eastern species like *F. sandersi* (Osborn) but readily differentiated from this and all other *prairiana* group species by the short, blunt subgenital plates (Fig. 6).

Figure 11. Female, bases of valvulae. Within *Flexamia* these structures provide a means for specific identification of female specimens.

Discussion

Osborn and Ball (1898) first associated *Flexamia* with *Muhlenbergia* in the description of *Flexamia imputans* in 1898. The recent transfer (Peterson et al. 2010) of *Redfieldia flexuosa* (Thurb.) Vasey to *Muhlenbergia* as *M. ammophila* and this publication brings the total to twelve of 45 *Flexamia* species documented using *Muhlenbergia* as their host. All of the known host species are found in 2 of the 5 subgenera and sections of *Muhlenbergia—Pseudosporobolus* and *Muhlenbergia*. (Peterson et al. 2010; Paul Peterson, pers. comm. 2014).

While *M. torreyana* may be characterized as a relatively overlooked part of the eastern US flora, *Flexamia* is, thanks largely to the efforts of the late Bob Whitcomb, a very well-studied non-vector genus of North American Cicadellidae. As of this publication, host-plant associations (at least to genus) are known for 39 of the 45 valid species. Online range maps and photographs (Leafhopper Distribution Maps; Bugguide) exist for a number of species, there is a recent revision (Whitcomb and Hicks 1988), phylogeny (Dietrich et al. 1999), and recent new species description (Bess and Hamilton 1999).

The relative abundance of *M. torreyana* in the Pine Barrens suggests that it is the epicenter of a host with a very limited distribution (Fig. 12). But to date, as no attempt has been made to look for *F. whitcombi* in Tennessee and the coastal plain of North Carolina where *M. torreyana* occurs, the extent of its range is unclear. The Pine Bar-

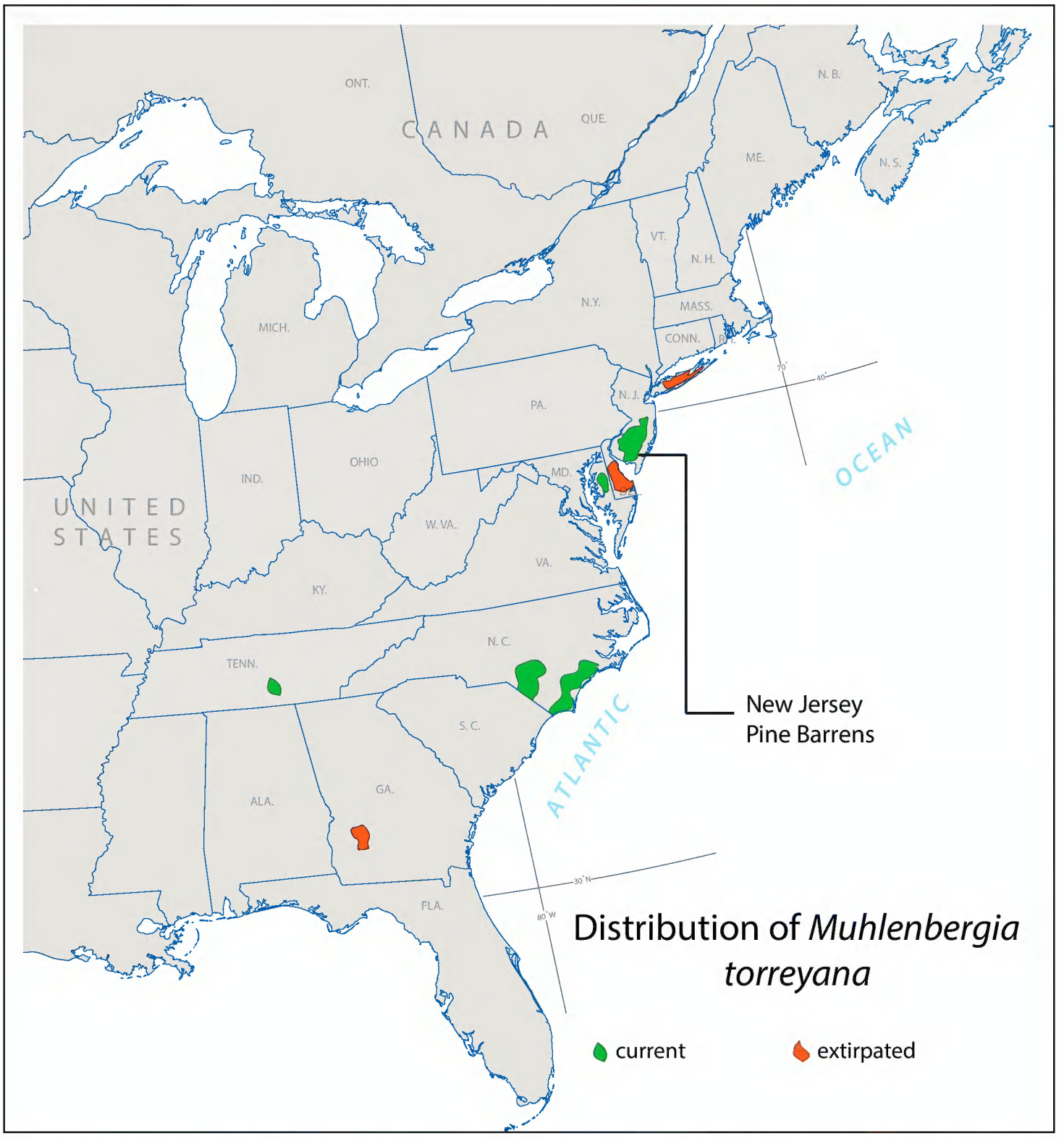

Figure 12. Distribution of *Muhlenbergia torreyana* and location of the Pine Barrens. Modified from data found on the Grass Manual on the Web and BONAP's North American Plant Atlas.

rens are already suffering the effects of a warming climate, as evidenced by the recent irruption there of the Southern Pine Beetle (Gillis 2013). Should the effects of climate change or other anthropomorphic pressures cause the local extinction of the host (as has apparently already occurred elsewhere in its range), there will be little opportunity for the survival of this *Flexamia*. But that might be said of most species described today (Dirzo et al. 2014, Kolbert 2014). The description of any new species may serve as a catalyst for additional research, and this will be best accomplished while the species still can be found in nature—something that can no longer taken for granted. To delay the publication of a species description until the time of a genus revision is to deny

the pace of change in the natural world in the 21st century and may consign said new species to a future status of "known from a single collection", or, "presumed extinct, life history unknown".

Key to the males of the *serrata* species group

1	Caudoventral margin of pygofer distinctly thickened, embrowned and terminating ventrally as a denticulate knob; on *M. torreyana*..... ***whitcombi* sp. n.**
–	Caudoventral margin of pygofer not particularly embrowned or thickened, ventral margin lacking process; on *M. richardsonis* **2**
2	Apical portion of aedeagus with 5 processes ..... ***huroni***
–	Apical portion of aedeagus with 6 processes ..... ***serrata***

Acknowledgments

Dr. Gerry Moore of the Natural Resources Conservation Service in Greensboro, NC kindly led me to the host plant in the field. His assistance greatly facilitated the discovery of this species. The photos of *M. torreyana* posted online by Uli Lorimer of the Brooklyn Botanic Garden were the catalyst for this investigation. Both Gerry Moore and Uli Lorimer shared their time and botanical knowledge of the Pinelands ecosystem. Laura Robinson, Botanist at the NC Natural Heritage Program, provided information about pinebarren smokegrass populations in North Carolina. Virginia Scott and Deane Bowers, Collection Manager and Curator respectively of the Entomology collection at the University of Colorado, provided lab space; Dr. David Stock graciously provided access to the electron microscope. My thanks to two anonymous reviewers for their helpful critiques of the manuscript. Publication of this article was funded by the University of Colorado Boulder Libraries Open Access Fund.

Dedicated to my father, Robert L. Hicks 1922–2012.

References

Bess JA, Hamilton KGA (1999) A new *Flexamia* (Homoptera: Cicadellidae: Deltocephalinae) from Southern Michigan. The Great Lakes Entomologist 32(1&2): 9–14.

Bugguide (n.d.) Genus *Flexamia* http://bugguide.net/node/view/149514/bgimage

BONAP: North American Plant Atlas (n.d.) http://bonap.net/napa [accessed 3.X.2014]

Caiazza N, Fairbrothers DE (1980) Threatened and endangered vascular plant species of the New Jersey Pinelands and their habitats. Report for the New Jersey Pinelands Commission, 38 pp.

Dietrich CH, Whitcomb RF, Black WC (1997) Phylogeny of the grassland leafhopper genus *Flexamia* (Homoptera: Cicadellidae) based on mitochondrial DNA sequences. Molecular Phylogenetics and Evolution 8(2): 139–149. doi: 10.1006/mpev.1997.0415

Dirzo R, Young HS, Galetti M, Ceballos G, Isaac NJB, Collen B (2014) Defaunation in the Anthropocene. Science 345: 401–406. doi: 10.1126/science.1251817

Gillis J (2013) In New Jersey Pines, Trouble Arrives on Six Legs. New York Times, December 2, 2013: A1. Print.

Kolbert E (2014) The Sixth Extinction. Henry Holt and Company, New York, New York, 319 pp.

Leafhopper Distribution Maps: *Flexamia* (n.d.) http://spot.colorado.edu/~hicks/flex_spp.html

Natureserve (2015) NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, VA. U.S.A. http://explorer.natureserve.org [accessed 3.III.2015]

New Jersey Department of Environmental Protection (2013) List of Endangered Plant Species and Plant Species of Special Concern. http://www.nj.gov/dep/parksandforests/natural/heritage/njplantlist.pdf

North Carolina Natural Heritage Program http://portal.ncdenr.org/web/nhp/ [accessed 3.III.2015]

Oman PW (1949) The Nearctic Leafhoppers (Homoptera: Cicadellidae). Memoirs of the Entomological Society of Washington 3, 253 pp.

Osborn H, Ball ED (1898) Studies of North American Jassoidea. New species, dimorphic forms and early stages of Jassidae. Davenport Academy of Natural Sciences Proceedings 7: 74–100.

Peterson PM (2003) *Muhlenbergia*. In: Barkworth et al. (Eds) Flora of North America vol. 25. http://herbarium.usu.edu/webmanual

Peterson PM, Romaschenko K, Johnson GP (2010) A phylogeny and classification of the Muhlenbergiinae (Poaceae: Chloridoideae: Cynodonteae) based on plastid and nuclear DNA sequences. American Journal of Botany 97(9): 1532–1554. doi: 10.3732/ajb.0900359

Sorrie BA, Van Eerden B, Russo MJ (1997) Noteworthy Plants from Fort Bragg and Camp MacKall, North Carolina. Castanea 62(4): 239–259.

Whitcomb RF, Hicks AL (1988) Genus *Flexamia*: new species, phylogeny, and ecology. Great Basin Naturalist Memoirs No. 12: 224–323.

Young DA Jr, Beirne BP (1958) A taxonomic revision of the leafhopper genus *Flexamia* and a new related genus (Homoptera, Cicadellidae). United States Department of Agriculture Technical Bulletin 1173, [ii] + 53 pp.

Zaremba RE, Lamont EE (1993) The Status of the Coastal Plain Pondshore Community in New York. Bulletin of the Torrey Botanical Club 120(2): 180–187. doi: 10.2307/2996948